4.10 City of Indianapolis Stormwater Green Infrastructure Guidance: Filters

Filters Fact Sheet
Filters Technical Design Specification
Filters O & M Manual

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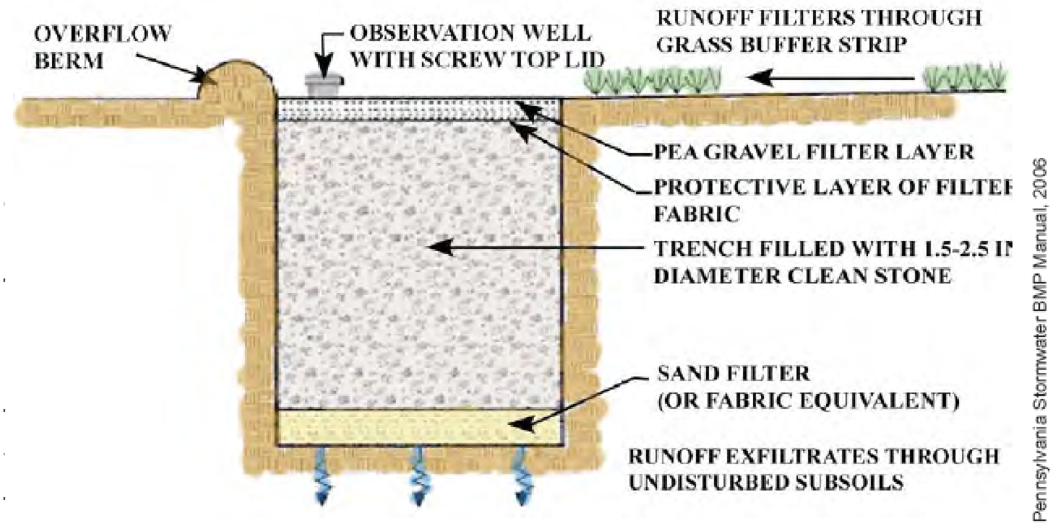
4.10 Filters

Filters are structures or excavated areas containing a layer of sand, compost, organic material, or other filter media. They reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants. Filtered stormwater may be infiltrated or released to a sewer or receiving water. Depending on design, the filter media may provide significant detention time or may be combined with an outlet control. Filters are best used in high density urban areas where there is little opportunity of clogging from drainage areas with high pervious cover or high sediment yield sites.

There are three primary types of filters: surface, perimeter and underground filters.

- Surface filters can be an excavated trench or concrete structure.
- Perimeter filters are typically enclosed vaults located along the edge of parking areas.
- Underground filters are primarily used for areas where available space is extremely limited.

When properly designed, constructed and maintained, filters have the ability to remove 80% of the total suspended solids load in urban runoff.



FILTER WITH INFILTRATION

key elements:

- Acceptable technique on sites where vegetated systems are impractical.
- Surface ponding that drains down in no more than 72 hours.
- Filter medium (typically sand, peat, or a mixture) removes pollutants and provides some travel time.

- Typically two or more chambers are used in a filter system. The first is the sedimentation chamber or forebay which removes floatables and heavy sediments. The second is the filtration chamber which removes pollutants from the runoff by filtering through the sand bed or other filter media.

- Underdrain allowed on sites where infiltration is infeasible, or where a filter is used in combination with other practices.

- Flow splitter or positive overflow bypasses large storms. Typically an 'off-line' storm water quality system. To control flow rate, filters are usually combined with another structural control.

- Maintenance required to maintain capacity of system.

- Observation well is required for visual inspection.

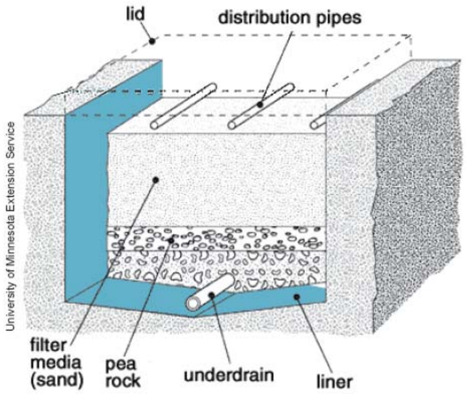
Potential applications			**Stormwater regulations**		
				Infiltration	No Infiltration
Residential Subdivision:	Limited		Water Quality Benefit	Yes	Yes
Commercial:	Yes		Volume Reduction	Yes	No
Ultra Urban:	Yes		Attenuation Benefit	Yes	Yes
Industrial:	Yes				
Retrofit:	Yes				
Highway Road:	Yes				

acceptable forms of pre-treatment

- Filter strips
- Appropriate prefabricated and proprietary designs
- Swales
- Sediment forebays
- Bioretention
- Planter boxes

Stormwater Filters in the Urban Landscape

Stormwater filters are suitable for sites without sufficient surface area available for vegetated bioretention basins. Filters are designed to either infiltrate or to treat and convey runoff to a disposal point. The two biggest differences between a filter and a bioretention basin, as defined in this manual, are surface vegetation and the use of underground containment structures. Vegetated basins often include a filtering layer that may be designed according to the guidelines in this section. Filters are recommended as a viable Stormwater Quality Practices for use in:



SAND FILTER WITH UNDERDRAIN.

- Parking lots
- Roadways and Highways
- Light Industrial sites
- Transportation facilities
- Fast food and shopping areas
- Waste Transfer Stations
- Urban Streetscapes

Filters may be visible from the surface or completely subsurface as shown in the two figures below . They may be designed as a single large chamber or filter bed (often with a small chamber or forebay for pretreatment) or as a long, narrow underground structure at the perimeter of a parking lot. Larger underground filter structures are used where space is limited and contributing areas are of high density.

Components of a Stormwater Filter System

Stormwater filters can be designed to infiltrate all or some of the flow. Components of stormwater filter system include:

STORMWATER FILTER

VEGETATED FILTER

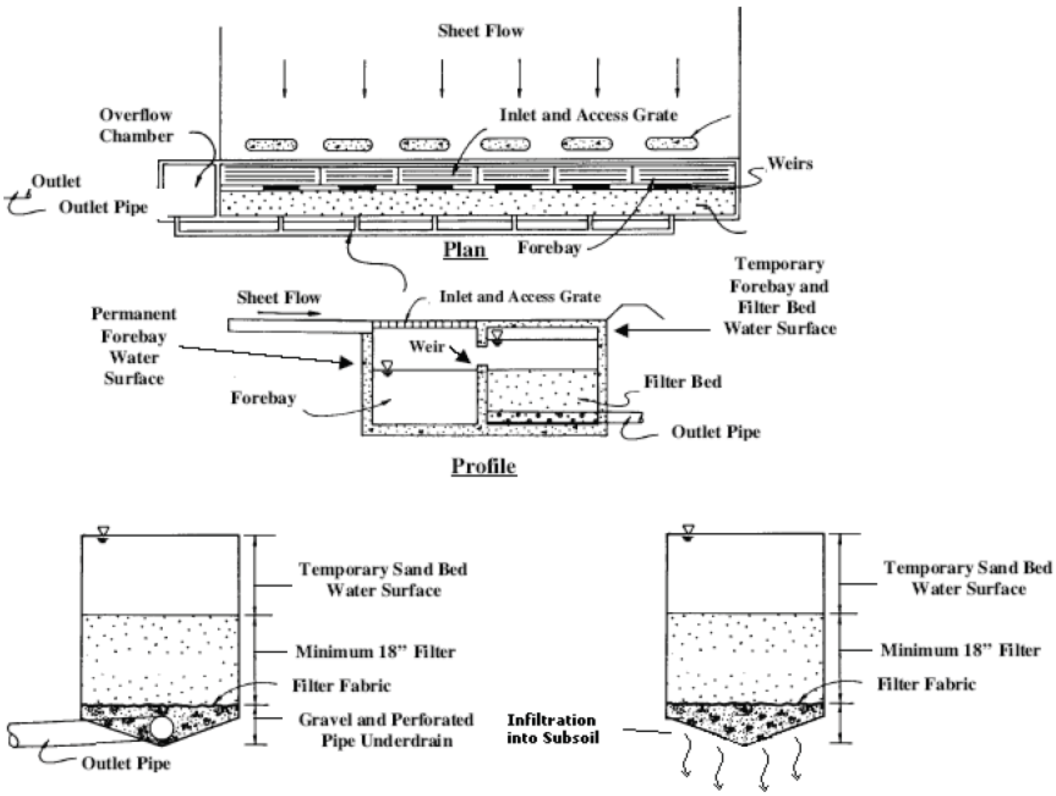
- Excavation or container
- Pretreatment
- Flow entrance/inlet
- Surface storage (ponding area)
- Filter media
- Underdrain, if required
- Positive overflow

Excavation or Container

The filer media may be contained in a simple trench lined with a geotextile, or it may be contained in a more structural facility such as concrete. In either case, the container may be designed either to allow infiltration or to collect flow in an underdrain system.

Flow Entrance/Inlet

Flow may be introduced to a filter through any of the controls discussed in the Inlet and Outlet Controls Fact Sheet (Chapter 4.9). If stormwater does not enter as sheet flow, a flow spreader is required.



SURFACE SAND FILTER

Surface Storage (ponding area)

The filter allows water to pond during intense storms as water flows slowly through the filter media.

Filter Media

Stormwater flows onto filter media where sediments and other pollutants are separated from the stormwater. Filter materials such as sand, peat, granular activated carbon (GAC), leaf compost, pea gravel and others are used for water quality treatment. Coarser materials allow faster transmission, but finer media filters particles of a smaller size. Sand has been found to be a good balance between these two criteria (Urbonas, 1999), but different types of media remove different pollutants. While sand is a reliable material to remove TSS, (Debusk and Langston, 1997) peat removes slightly more TP, Cu, Cd, and Ni than sand. Depending on the characteristics of the stormwater runoff, a combination of these filter materials will provide the best quality results. In addition to determining the degree of filtration, media particle size determines travel time in the filter and plays a role in meeting release rate requirements.

Underdrain (if required)

Infiltration is required where feasible unless the filter is combined with another facility that provides infiltration. Filters that do not infiltrate collect water through an underdrain system.

Positive Overflow

Filters must be designed to allow overflow or bypass of larger storm volumes. Flow splitters, diversion chambers, or proprietary devices can be used to divert a portion of flow to a filter in an off-line design. A design that is considered on-line allows water to flow across the surface of the filter before being discharged over a weir or other control.

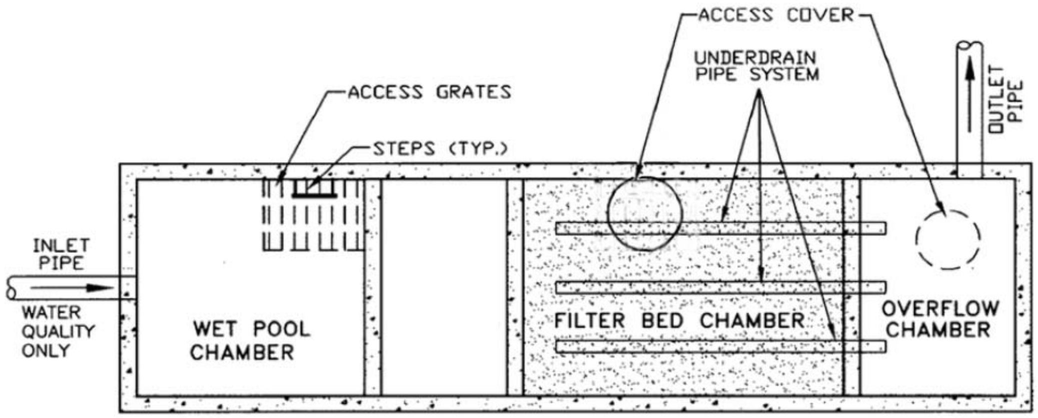
Recommended Design Procedures

- Determine the Water Quality and Quantity requirements for the site. See the City of Indianapolis Stormwater Specifications Manual.

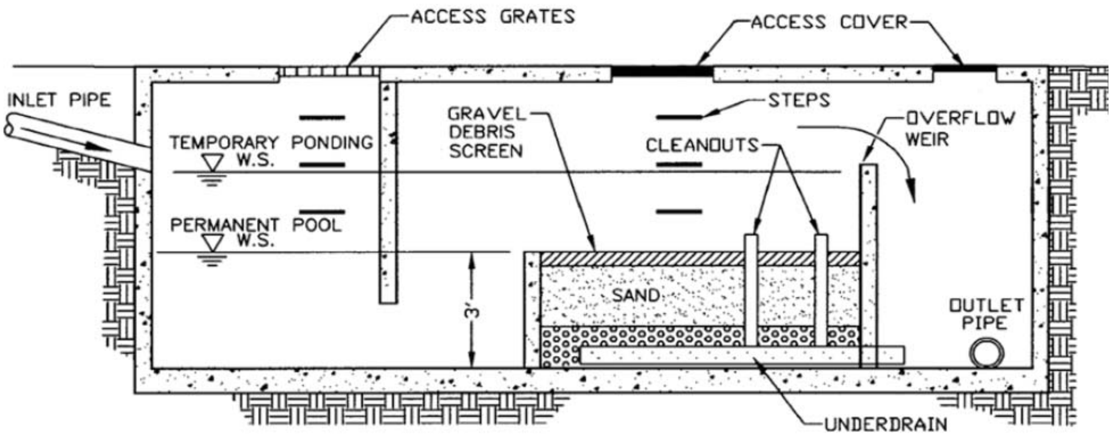
- Create a Conceptual Site Plan for the entire site and determine what portion of the stormwater control requirements the filters will meet. See the City of Indianapolis Stormwater Specifications Manual.

- Investigate the feasibility of infiltration in the area proposed for the stormwater filter. If infiltration is feasible, determine the saturated vertical infiltration rate. Design proceeds differently depending on the feasibility of infiltration.

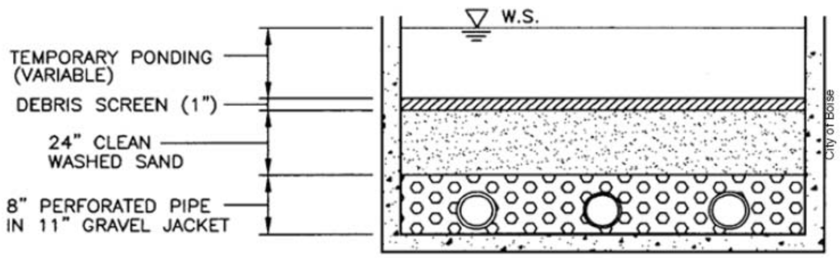
- Create a conceptual design for the stormwater filter.



PLAN VIEW



PROFILE



• The filter area may be estimated initially using Darcy's Law, assuming the soil media is saturated.

Af = (V x d) / [k x t (h + d)]

Af = Surface area of filter bed (square feet)

V = Volume to be managed, i.e. water quality volume (cubic feet)

d = Depth of filter media (feet)

t = Filter bed drain time (days)

h = Head (average in feet)

k = Saturated hydraulic conductivity of filter media (feet/day)

k Design values: sand = 3.5 feet/day; peat = 2.5 feet/day; leaf compost = 8.7 feet/day

- For filters designed for infiltration, estimate the total storage volume and adjust area and/or depths as needed to provide required storage.

Table 4.10.1: Suggested Starting Design Values for Ponding and Media Depths	
Average Ponding Depth	3-6 inches
Filter Media Depth	18 – 30 inches

- Using stormwater filter area and the saturated vertical infiltration rate of the filter media, estimate the drainage time for ponded surface water. The saturated vertical infiltration rate may be based on the estimated saturated hydraulic conductivity of the proposed filter materials. The maximum drain down time for the entire storage volume is 72 hours, but a surface drain down time of 24-48 hours is recommended. If storage does not drain in the time allowed, adjust pretreatment depth, filter media depth, and surface area. Adjust the design until the volume and drainage time constraints are met.

Consider an underdrain only under one of the following conditions:

- in areas with separate storm sewers or direct discharge to receiving waters where infiltration is infeasible and the filter system is needed only to provide water quality treatment;
- in areas with combined sewers where sufficient detention or travel time can be designed into the system to meet release rate requirements; or
- in combination with other SMPs where the system as a whole meets storage and release criteria.
- Design underdrains to minimize the chances of clogging. Pea gravel filters can be used for this purpose. Pea gravel filters should include at least 3 inches of gravel under the pipe and 6 inches above the pipe.
- Design any structural components required.
- Complete construction plans and specifications.

Materials

Stone Storage (if used)

- Stone used to provide additional storage shall be uniformly-graded, crushed, washed stone meeting the specifications of AASHTO No. 3 or AASHTO No. 5.

- Stone shall be separated from filter medium by a non-woven filter fabric or a pea gravel filter.

Filter Media

- Peat shall have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.

- Sand shall be clean, medium to fine sand, and have organic material meeting specifications of AASHTO M-6 (0.02” – 0.04”) or ASTM-C-33.

- Prefabricated filter media shall meet filter design and water quality specifications.

Piping

- Pipe shall have continuous perforations, smooth interior, and minimum diameter of 6 inches. High density polyethylene (HDPE) pipe shall meet specifications of AASHTO M252, Type S or AASHTO M294, Type S.

Construction Guidelines

- Areas for stormwater filters shall be clearly marked before any site work begins to avoid soil disturbance and compaction during construction.

- Permanent filters should not be installed until site is stabilized. Excessive sediment generated during construction can clog filter and prevent its function prior to post-construction benefits.

- Structures such as inlet boxes, reinforced concrete boxes, inlet controls, and outlet structures should be constructed in accordance with manufacturer’s guidelines or Engineer’s guidance.

- Excavated filters or structural filters that infiltrate should be excavated in such a manner as to avoid compaction of the sub-base. Structures should be set on a layer of clean, lightly compacted gravel specified as AASHTO No. 57.

- A layer of permeable non-woven geotextile should underlie infiltration filters.

- Place underlying gravel/stone in minimum 6 inch lifts and lightly compact. Place underdrain pipes in gravel during placement (if applicable).

- Wrap and secure non-woven geotextile to prevent gravel/stone from clogging with sediments.

Maintenance Guidelines

For filters located entirely underground, unobstructed access for must be provided over the entire sand filter, including inlet and outlet pipe structures, by either doors or removable panels. Ladder access is required for vault heights greater than 4 feet.

Table 4.10.2: Filter Maintenance Guidelines	
Activity	**Schedule**
Rake filter media surface for the removal of trash and debris from control openings. Repair of leaks from the sedimentation chamber or deterioration of structural components.	As needed
Inspect filter for standing water (filter drainage is not optimal) and discoloration (organics or debris have clogged filter surface).	Quarterly
Removal of the top few inches of filter media and cultivation of the surface when filter bed is clogged. Clean out accumulated sediment from filter bed chamber. Clean out accumulated sediment from sedimentation chamber.	Annually
Maintain records of all inspections and maintenance activity.	Ongoing

In areas where the potential exists for the discharge and accumulation of toxic pollutants (such as metals), filter media removed from filters must be handled and disposed of in accordance with all State and Federal Regulations.

Winter concerns

Indiana's low temperature dips below freezing for about four months out of every year, and surface filtration may not take place as well in the winter. Peat and compost may hold water, freeze, and become impervious on the surface. Design options that allow direct sub-surface discharge into the filter media during cold weather may help overcome this condition.

Siting constraints:

For a surface filter that infiltrates into the existing soil, the minimum distance between the bottom of the filter and the elevation of the seasonally high water table is 2 feet.

To protect the aquifer, infiltration shall not be used on hot spot sites or within well field protection areas.

Note:

Design of stormwater filters are not limited to the examples shown within this text. Successful stormwater management plans will combine appropriate materials and designs specific to each site.